BELLCOMM, INC.
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D. C. 20024

SUBJECT: Current Candidates for Lunar Environs Timelines on the G1 Mission - Case 320

DATE: March 14, 1969

FROM: P. Benjamin

MEMORANDUM FOR FILE

INTRODUCTION

Three alternatives are currently being considered as possible G1 mission timelines in the lunar environs. All three include a split LM activation and checkout with a relatively short second section and an interposed sleep period. They differ in the order in which EVA and sleep on the lunar surface are scheduled. The first plan schedules sleep after EVA, the second schedules sleep before EVA, and the third is a compromise developed at MSC which combines both options and requires a real time decision by the crew to select a desired mode. Two decision points are provided--one before EVA and the other before TEI.

The descriptions of the specific activities, the work/rest cycle scheduling, and the trajectory constraints required for the timeline construction are discussed in detail in a previous memorandum by the author.* Using the methodology described in the reference, a time matrix provides a framework for the comparison of the various options.

EVALUATION

The sleep after EVA timeline (Figure 1) closely approximates a nominal 16/8 work/rest cycle. The time between the orbital sleep period and sleep after EVA is 17 hours, and 15.5 hours elapse between sleep on the surface and the first Trans Earth Coast (TEC) sleep. The time matrix (Table 1) shows that this plan provides the minimum time in lunar orbit and the lowest value of maximum time awake. The time since sleep values indicate desirable performance levels at touchdown and docking, and acceptable levels at EVA and TEI. This plan obtains the highest performance rating (as described in the reference cited above) of +3.

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*P. Benjamin, "An Analysis of Work/Rest Cycles and Crew Performance for Various Lunar Environs Timeline Configurations," Bellcomm Technical Memorandum 69-2033-1, March 3, 1969.

The sleep before EVA timeline (Figure 2) deviates somewhat from the ideal work/rest cycle. The scheduled surface sleep period occurs only 9.5 hours after sleep in orbit. A longer than nominal 18 hour day falls between surface sleep and sleep preceding TEI. This is the maximum time awake for this plan, as shown in Table 1, and this plan also has the longer 60 hour lunar orbit time. As with the sleep after EVA timeline, TD occurs at 6.5 hours after sleep, but docking occurs at 14.5 hours after sleep, very late in the day. EVA and TEI occur somewhat early in the work cycle, at about 3 hours. The performance rating of +1 is lower than for the sleep after EVA plan.

The third plan (Figure 3) recognizes the possible requirement for the rescheduling of sleep periods and provides in advance for real time decisions by the crew as to whether they desire sleep before or after EVA and before or after TEI. Thus the crew is given the opportunity, after completion of postlanding checkout and eating, to decide in real time whether to procede with EVA or to sleep. This decision point is viable only if the second portion of LM activation and checkout is short enough to provide the EVA opportunity relatively early in the work day. Similarly after completion of intervehicular transfer (IVT) and eating, the crew has a preplanned decision point to determine whether TEI or sleep will follow. This plan represents an advance in flight planning in that it overtly recognizes the need for possible real time modification of a fixed sequence of activities and plans in advance for alternate modes of operation at specific points.

As seen from Figure 3, the choice not to sleep at both decision points in this plan results in the sleep after EVA timeline shown in Figure 1. Similarly a choice of sleep at both points results in the sleep before EVA timeline shown in Figure 2. Figure 4 shows the real time decision plan (and thus also the previously described plans) on a time scale. The first decision point occurs only 9.5 hours after sleep, and thus the no sleep option seems a more probable choice. However, a poor sleep period in orbit could dictate a sleep choice before a physically demanding EVA.

If EVA first is chosen on the surface the second decision point occurs 10.5 hours after sleep, again indicating a more probable no sleep choice, unless sleep on the surface was inadequate. The sleep after EVA and sleep after TEI combination of choices (Figure 1) was discussed previously. As shown in the time matrix, the sleep after EVA but before TEI choice results in the same 17 hour maximum awake time as in the sleep after both events plan, but requires the long lunar orbital time of 60 hours. Performance at critical events is similar to the sleep after EVA plan, with an identical +3 performance rating.

If the sleep first option is chosen on the surface the second decision point occurs 18 hours after sleep, indicating a more probable sleep choice, and resulting in a configuration identical to the sleep before EVA plan (Figure 2). The results of the sleep before EVA but after TEI choice are shown in Table 1. A 23 hour day results from this combination. Although lunar orbit time is the lower 52 hour value TEI occurs after 20.25 hours in a day which also includes EVA, LO, and docking. This plan has the lowest performance rating of the four options, zero.

CONCLUSION

In summary, the real time decision plan represents an advance in timeline thinking in that it provides the pre-planned opportunity for real time decisions to choose work/rest options. The choice of sleep before EVA on the surface is somewhat more constraining in that a subsequent sleep after TEI choice in orbit results in a very long day. For the third to tenth hours of a surface stay, however, this option provides a more rested crew if abort is required. The choice of sleep after EVA on the surface provides a more realistic choice between the two options before TEI, and is thus more flexible. The consequences of decisions to skip sleep periods entirely are treated in detail in the reference cited previously, and are summarized in the last two columns of Table 1. It must be acknowledged, also, that relaxation of the nominal 16/8 work/rest cycle restriction opens up the possibility of numerous other alternatives such as 8/4 cycles.

To obtain maximum real time flexibility in a new and largely unknown environment it is suggested that the real time decision timeline be adopted for the first lunar landing mission. To maintain the decision points in a realistic fashion, however, the second portion of LM activation and checkout must not be expanded over its current length. To ensure maximum utility of the real time decision timeline its adoption should be reflected prominently in such documents as the flight plan and mission rules.

Peter Benjamin

2033-PB-scs P. Benjamin

Attachments
Figures 1, 2, 3, 4
Table 1

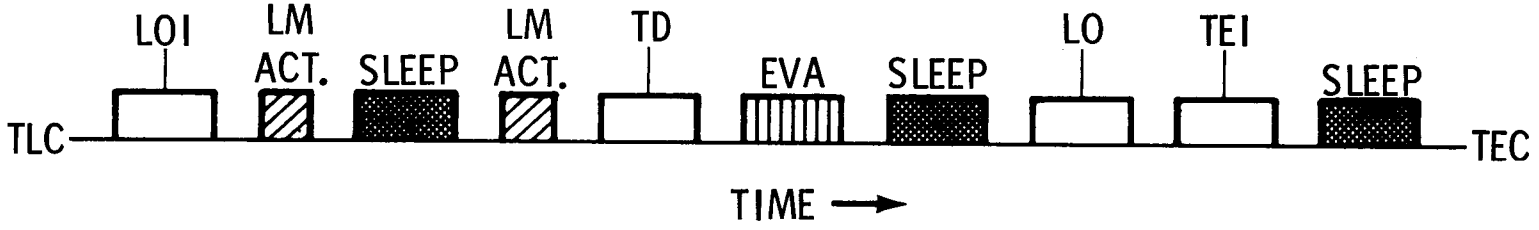

FIGURE 1 - SLEEP AFTER EVA

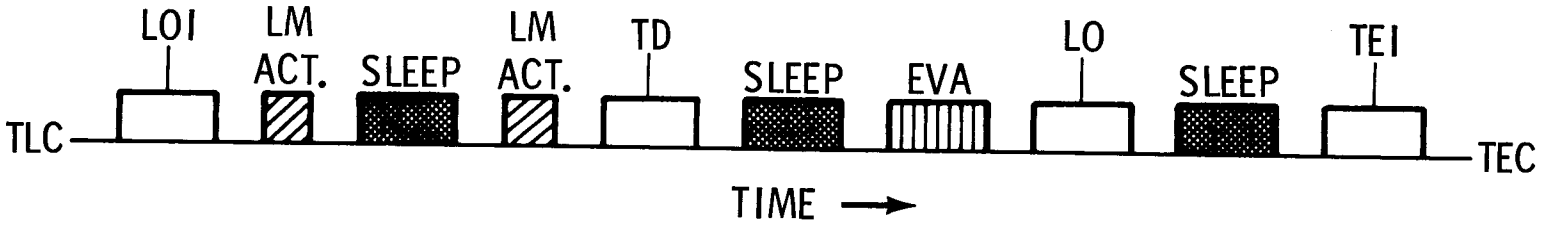

FIGURE 2 - SLEEP BEFORE EVA

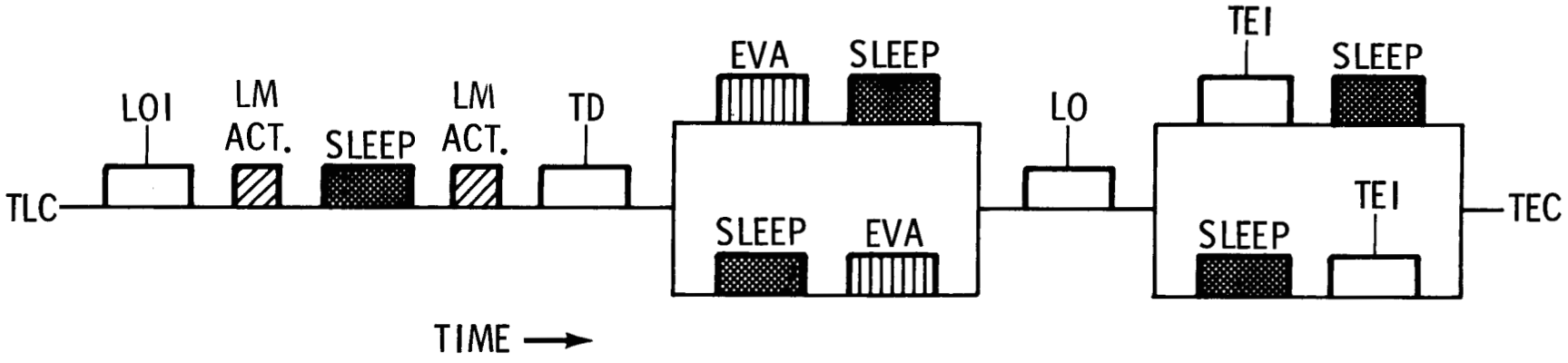

FIGURE 3 - REAL TIME DECISION PLAN

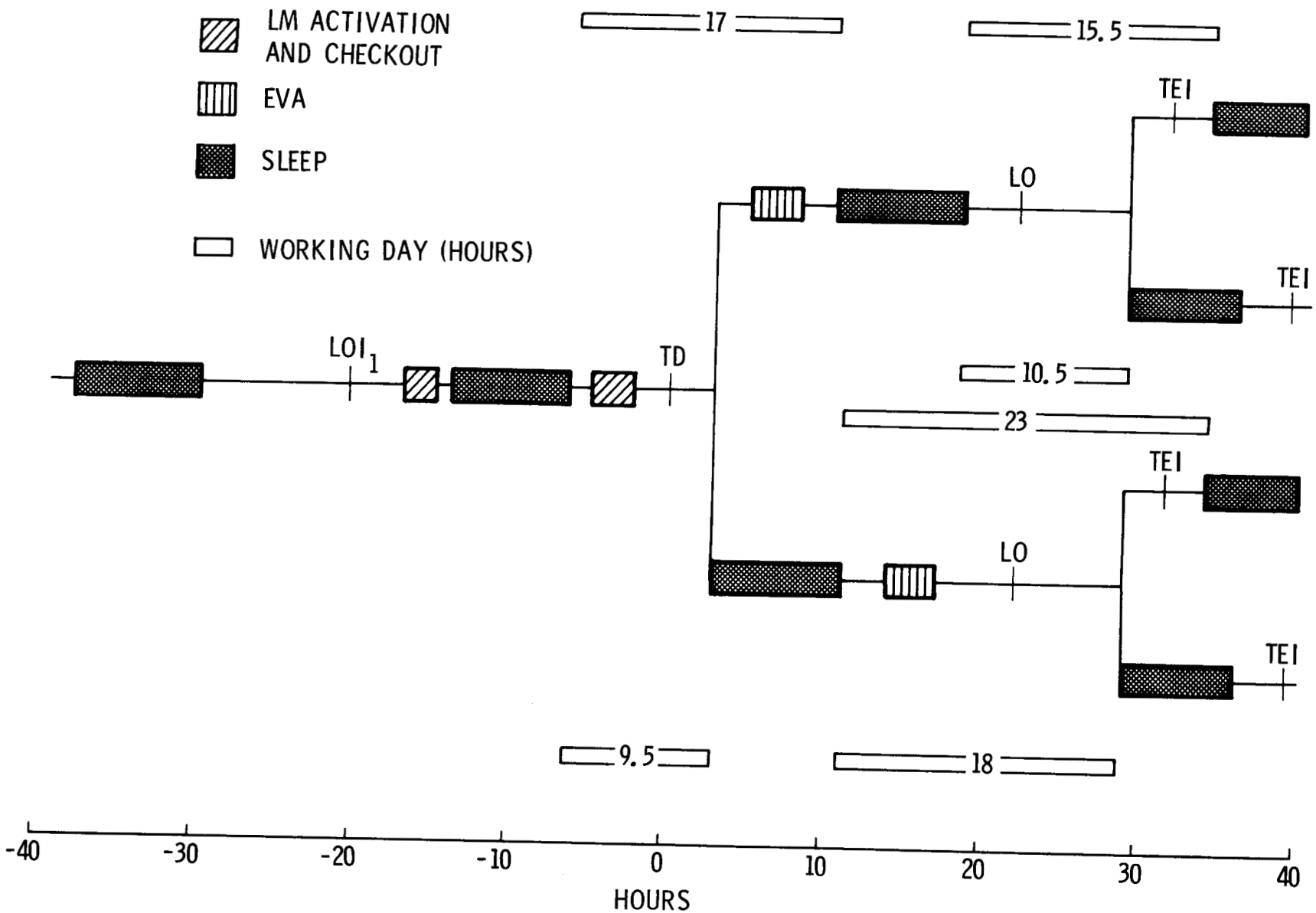

FIGURE 4 - REAL TIME DECISION TIMELINE

DECISION SEQUENCE	EVA SLEEP TEI SLEEP	SLEEP EVA SLEEP TEI	EVA SLEEP SLEEP TEI	SLEEP EVA TEI SLEEP	EVA LO SLEEP TEI	EVA LO TEI SLEEP
MAX TIME AWAKE	17	18	17	23	25.5	30.5
MIN TIME AWAKE	15	9.5	10.5	9.5	16	16
CSM TIME IN LUNAR ORBIT	52	60	60	52	50	42
TIME ON LUNAR SURFACE	22	22	22	22	12	12
PERFORMANCE:						
TIME SINCE SLEEP						
FOR TD	6.5	6.5	6.5	6.5	6.5	6.5
FOR EVA	11.5	3	11.5	3	11.5	11.5
FOR DOCKING	7	14.5	7	14.5	22	22
FOR TEI	12.75	3.25	3.25	20.25	3.25	27.75
PERFORMANCE RATING	+3	+1	+3	0	+1	-1

TABLE 1 - TIME MATRIX

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ABSTRACT

Three possible G1 mission lunar environs timelines are examined. Each has a split LM activation and checkout with a relatively short second section and an interposed sleep period. One plan schedules sleep after EVA and sleep after TEI. The second schedules sleep before EVA and sleep before TEI. The third provides for real time decisions between the designated activity and sleep at EVA and TEI.

It is concluded that the real time decision plan, which allows sleep before or after EVA and sleep before or after TEI, permits maximum real time flexibility. The pre-planned opportunity for real time modification of the activity sequence represents an advance in flight planning. Adoption of this timeline, however, requires an absolutely minimal second portion of LM activation and checkout. It is suggested that this plan be adopted and reflected prominently in such documents as the flight plan and mission rules.